# REFRACTORIES FOR THE GLASS INDUSTRY

UDC 666.1:666.76

## STAND ASSEMBLY OF A GLASS-FURNACE BOTTOM

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Translated from *Steklo i Keramika*, No. 8, pp. 30 – 34, August, 2010.

"BKO" JSC has perfected an assembly-stand technology for the elements of a glass-making furnace, first and foremost, the furnace bottom. Coordinated studies were performed to ensure that the accuracy of the stand meets the requirements: a stand with planarity deviations ± 0.5 mm was designed and built, the preparation technology (cutting and grinding) for the block articles for the assembly stand with minimum admissible deviations (linear dimensions ± 0.25 mm; inclinations less than 0.2 mm) was perfected, and the assembly stand technology itself was perfected. The technology developed was used to assemble other elements of the furnace: feed pans of the glass-forming machines, regenerator arches, and loading hoppers. An assembly stand makes it possible decrease substantially the assembly time of a glass-making furnace, lower the construction costs, and develop favorable conditions for laying other elements of the furnace, all which taken together increase the service life of a furnace.

***Key words:*** glass-making furnace, bottom bar, arched structures, assembly stand.

An assembly stand for separate building structures of industrial furnaces has been used comparatively recently for units and their critical components with a long service life. Examples are: the hearth of a domain furnace laid using carbon blocks, the glass-making tank lined with fused-cast baddeyelite-corundum (bacor) articles — blocks for the walls and bottom plate.

Preliminary stand assembly of individual elements as well as the entire glass-making furnace as a whole at the manufacturing plant has already become a common practice for many foreign manufacturers and is one of the mandatory conditions for choosing a supplier of refractory materials. In Russia, however, suppliers of fused-cast bacor and corundum articles are the main users of this practice. The fireclay bar for lining the furnace bottom was delivered by domestic refractory enterprises on in individual blocks, and masonry specialists with special technical equipment were needed to fit the articles in place (stone cutting machine tools, grinding machines, and so forth) in order to lay the bottom.

The advantages of the preliminary assembly on a stand are obvious. The manufacturer can see the drawbacks in the implementation of individual element in a structure and correct they in a timely manner — before the used receives them. The preparation and assembly of the articles in the manufacturing plant are done on specialized equipment using special devices and methods for conducting the work, as a result of which assembly quality increases. The user can not only see the entire structure and check the geometric dimensions and technical characteristics but also decrease the substantially the time and resources spent on the assembly of the structure at the user's location and prepare other units of the furnace for high-quality assembly without additional leveling procedures.

Under conditions where every day of furnace down time and every work day of the contracted organization are counted it is especially important to decrease the time required for the construction-assembly work. For this reason, having been invited to participate in a tender to supply 92 tons of refractories for the bottom of a tank furnace at the Kamyshin Glass-Container Works, which is a part of the transnational company St. Gobain. The tender submitted by "BKO" JSSC specialists, applying their best efforts, won. By this time "BKO" JSC already had experience in stand assembly of the subchecker arches of regenerators, made from MLS-62 mullite blocks for the Gomel' Glass-Container Works and the "Dimitrovsteklo" (furnace designs by the German company Horn) and loading-hopper arches made of ShSU-33 fireclay blocks for the "Russian Glass Works" JSC (design by "Giprosteklo").

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0361-7610/10/0708-0255 

**Fig. 1.**

The St. Gobain Company passed to "BKO" JSC specialists the requirements of the stand assembly and its individual elements.

**Main Requirements of the St. Gobain Company for the Stand Assembly and Its Individual Elements**

The bottom of the glass-making furnace is assembled on a stand without any lining materials placed under the articles to correct planarity deviations of the stand's surface.

The bottom of the glass-baking furnace can be assembled element-wise:

– melting zone;
– fining zone;
– zone of the bottom under the loading hoppers;
– zone of the bottom under the extraction channel.

Each element must be completely assembled in accordance with the customer's blueprints. The assembly of individual elements in parts is not permitted.

The admissible deviations of the dimension of the assembly are:

– with respect to length and width from 0 to – 8 mm (with melting zone length and width 10 and 9 m, respectively);

– the distance between the axes of the openings from 0 to – 5 mm;

– the distances of two diagonals between individual elements of the working surfaces of an assembly should not exceed ± 2 mm;

– the height deviations between neighboring articles in an assembly should not exceed 1 mm;

– the magnitude of the gap between neighboring articles should not exceed 1.2 mm.

**Stand**

To accomplish stand assembly one needs a stand. Having analyzed the existing data on the construction of glass-making furnaces, after consultations with Russian specialist at St. Gobain Company the dimensions of the stand assembly were chosen as $12 \times 18$ m. These dimensions were chosen because the assembled structure of the bottom of practically any finished stand must fit within the stand and it must fit in the storage area of he finished products without damaging the products.

The construction of the stand must be rigid, so as not to become deformed in the loaded state. A weld construction made from I-beam girders and rails was rejected because of the impossibility of straightening out the deformations of the I-beam girders and rails occurring manufacturing, shipment, and assembly which made it possible to satisfy the nonplanarity condition for the stand: the height deviations between individual elements of the working surface of the stand should not exceed ± 1.0 mm and between neighboring elements of the working surface of the stand must fall between 0 and + 1 mm or 0 and – 1 mm.

The designers of the planning – design division of "BKO" JSC proposed a novel assembly construction stand, consisting of a reinforced concrete base, a rigid welded frame built from I-beam girders and an exterior facing, bolted together, made from rolled metal with compensators of the deformations of the I-beam girders. As a result of control measurements performed when the stand was delivered for operation, the nonplanarity of the individual elements of the exterior surface ranged from – 0.2 to + 0.6 mm. This gave the necessary conditions for assembling the furnace bottom without using liner materials to compensate for the nonplanarity (Fig. 1). The design and construction of the stand required 1.5 months of intense work.

**Preparation of the Block for Assembly**

It appears at first glance that calcined block-shaped articles formed in a press do not require preparation: they possess the minimum deviations from the standard dimensions (± 2 mm), have a uniform structure and properties, but to ensure that articles are pushed out after formation the mold must have a technical bias. The bias adopted conventionally by Russian manufacturers is 1% or 1 mm per 100 mm of the height of the article. For 40 – 80 mm high articles (most standard formats) the differences of the geometric dimensions at the top and bottom with respect to the pressing axis are tenths of a millimeter and are not noticeable in measurements performed using instruments with 1 mm divisions. For 300 mm blocks, the difference of the dimensions becomes noticeable and when obtaining the articles, on the whole according to the tolerances satisfying GOST 7151 requirements, the top of the article will be in the plus tolerance range in length and width while the bottom of the article will be in the minus range. For this reason, the Fritz-Mueller (Germany) K-5000 mold was rebuilt to obtain articles only in the plus tolerance range.

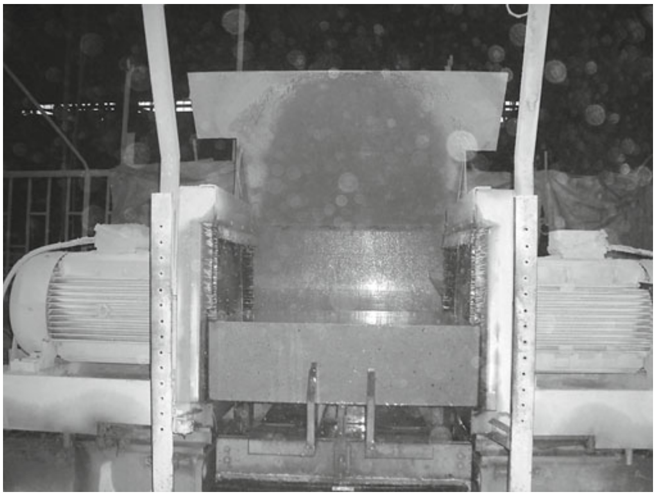

**Fig. 2.**

**Fig. 3.**

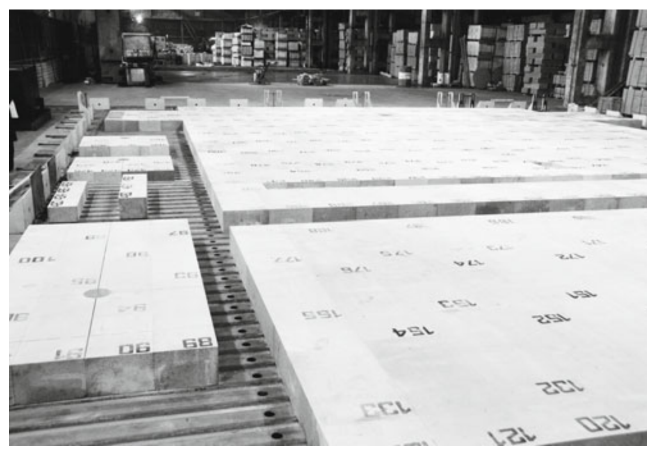

**Fig. 4.**

To ensure that the requirements with respect to the minimum deviation of the dimensions of the assembled bottom are met and the diagonals of all elements of the assembly are the same, which serves as a check on the rectilinearity of all connections (it is well known that the diagonals are observed to equal only for a rectangle), after calcination all six faces of each block were ground on the Austrian grinder "Wassmer" (Fig. 2). Some blocks with nonstandard dimensions (length less than 1000 mm, width less than 400 mm, thickness less than 300 mm) were obtained by cutting standard blocks with dimensions $1000 \times 400 \times 300$ mm on a stationary cutting tool with a round saw blade. The cut blocks were also ground on all sides. In some articles openings with diameter 200 and 250 mm were drilled under the thermocouples and electrons, respectively.

Successful assembly of the articles on the stand is accomplished only if the following stringent requirements are met with respect to the tolerances:

– length, width, and height deviations $\pm$ 0.25 mm;

– bias (deviation from a right angle) on all sides no more than 0.2 mm.

Each block was measured, before and after grinding, on a checking plate (Fig. 3), and permission for packing the elements on the stand was given only after the established conditions were met. The geometric dimensions were measured with a Vernier caliper with scale division 0.1 mm and the biases were measured with an angle bracket and standard feeler gages.

## Assembly of Articles on a Stand

The technology for assembling articles on a stand was developed and refined during the entire period of assembly. Since there was no experience, the initial conditions were matched with the Russian specialists at the St. Gobain Company. The chief engineer at "St. Gobain Kavminsteklo" O. A. Andreev provided invaluable assistance in this work.

Before the articles are articles were arranged, the stand was marked and every basis axis (so-called red or references lines) was marked. Assembly was done in a coordinated order. After each row was assembled, the length, width, height, and planarity of each lateral surface were checked. After three rows were assembled the deviations of the dimensions of the diagonals are checked. Subsequently, the dimensions of the diagonals were checked after each row was added. The bottom under the loading hoppers was assembled separately from the glass-making zone (Fig. 4). The bottom of the fining zone is structurally located at below the level of the glass-making zone. In agreement with the specialists at the St. Gobain Company, the bottom of the fining zone was assemble on the same level as the glass-making zone, separating them by a 500 mm wide opening in order to perform control measurements. At the completion of assembly each arti-

**TABLE 1.** Results of Measurements of the Geometric Dimensions of the Stand Assembly of a Furnace Bottom

| Furnace-bottom zone | Dimension name | Blueprint size, mm | Actual size, mm |
|---|---|---|---|
| Melting | Length | $10{,}021^{+0}_{-8}$ | 10,018 |
| | Width | $9050^{+0}_{-8}$ | 9049.5 |
| | Difference of the lengths of two diagonals | 7 | 1 |
| | Distance between the basal line and the axes of the openings under a thermocouples | 2200 ± 5 | 2201 |
| | | 2200 ± 5 | 2197 |
| | Distance between the basal line and the axes of the openings under electrodes | $600^{+0}_{-5}$ | 600 |
| | | | 598 |
| | | $1600^{+0}_{-5}$ | 1598 |
| | | | 1600 |
| | | $2600^{+0}_{-5}$ | 2596 |
| | | | 2598 |
| | Distance between the basal line and the axes of the openings under electrodes | $1500^{+0}_{-5}$ | 1495 |
| | | | 1495 |
| | | | 1495.5 |
| | | | 1495.5 |
| | | | 1495 |
| | | | 1496 |
| Fining | Length | 3400 ± 3 | 3398.5 |
| | Width | $9050^{+0}_{-8}$ | 9048.5 |
| | Difference of the lengths of two diagonals | 5 | 1 |
| | Distance between the basal line and the axes of the openings under a thermocouple | 250 ± 2 | 250 |
| | | | 250 |
| | Distance between the basal line and the axes of the openings under electrode | 250 ± 2 | 250 |
| | | | 250 |
| Channel | Length | $2638^{+0}_{-5}$ | 2934 |
| | | | 2635.5 |
| | Width | $1800^{+0}_{-3}$ | 1799 |
| | Difference of the lengths of two diagonals | 1.6 | 1 |
| | Distance between the basal line and the axes of the openings under electrode | $749^{+0}_{-5}$ | 748.5 |
| Loading hopper, left side | Length | $2500^{+0}_{-5}$ | 2499 |
| | Width | $1325^{+0}_{-5}$ | 1324 |
| | Difference of the lengths of two diagonals | 1.4 | 0.5 |
| Loading hopper, right side | Length | $2500^{+0}_{-5}$ | 2499 |
| | Width | $1325^{+0}_{-5}$ | 1324 |
| | Difference of the lengths of two diagonals | 1.4 | 0.3 |

cle was numbered in accordance with the order in which it was arranged at the customer's location.

The linear dimensions were checked using the Leica DISTO™ A3 laser rangefinders (Fig. 5), construction tape measures with 1 mm scale division, angle brackets, a collection of calibrated feeler gauges, and other instruments.

**Reception of the Stand Assembly of the Furnace Bottom**

The stand assembly was received by representatives of the customer.

A commission made all the required measurements of the linear dimensions (lengths, widths, and diagonals), devia-


Fig. 5.

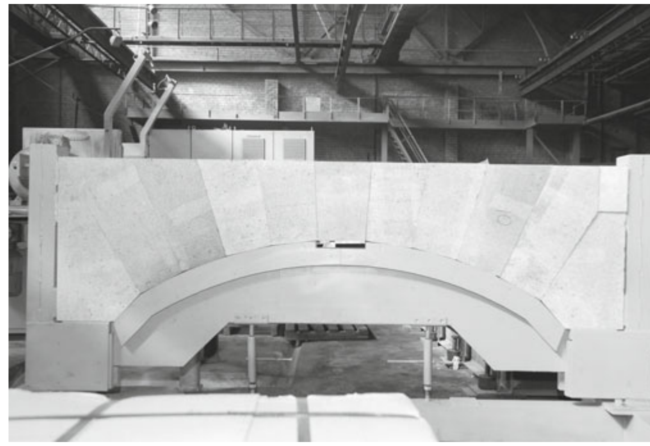

Fig. 6.

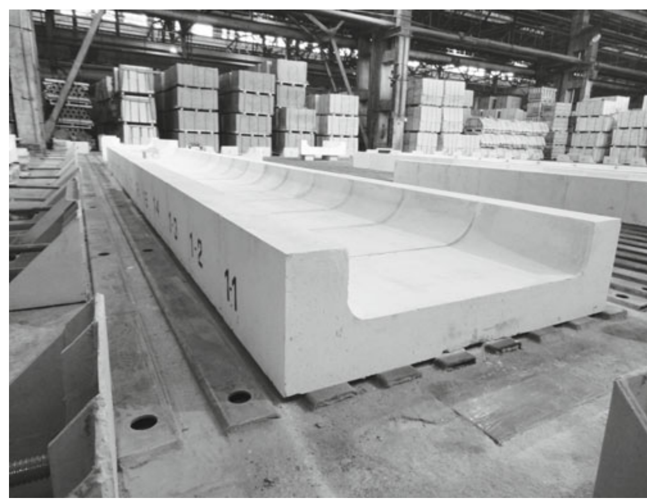

Fig. 7.

tions in height, nonplanarity of the side surfaces, gaps between the articles in an assembly of each composite element of the bottom: melting zone, fining zone, zone of the loading hoppers. The results of the measurements, which are presented in Table 1, show that all norms are met with a considerable margin.

### Stand Assembly of Other Elements of Glass-Making Furnaces

"BKO" JSC obtained the first experience in the stand assembly of an element of a glass-making furnace in 2008. Subchecker arches for regenerators were made, according to an order by "Stal'proekt" JSC for Gomel' Glass-Container Works (project of the Horn Company (Germany)), from MLS-62 mullite blocks; one requirement of the customer was that a preliminary stand assembly was to be made. For this, a compact sectional stand which was used to assemble the blocks (Fig. 6) was constructed. Representatives of the customer received the assembled arches at the manufacturing plant. In a review "Stal'proekt" JSC noted the high quality of the work: complete corresponds with the physical-chemical indicators with the requirements of the standards, and geometric dimensions with the requirements of the designers; the arch structures assembled on the stand of length 2500 mm showed deviations of no more than 3 – 5 mm in length and no more 1 mm in height. All elements were cut out of large-block mullite articles, the accuracy of the geometric dimensions was attained by grinding each article separately, each article of the arch was numbered, and the packaging preserved the structure.

Subsequently, structurally similar subarch were pre-assembled on a stand for "Dmitrovsteklo", the arches of the loading hoppers made of ShSU-33 fireclay blocks were made for the Ruzaev Glass Works, and flat arches generators were made for "Salavatsteklo."

Immediately after the furnace bottom was received by the Kamyshin Glass-Container Works the chutes for feeding the glass-forming machines at the "Krasnoe Ékho" Glass works were pre-assembled on a new stand. Borovichi Refractory Works has been delivering for six years now sets of shuts for feeders at difference glass works; the grinding of sections of chutes was perfected in past years, and this year stand assembly of three sets of chutes was completed for the first time (Fig. 7).

### CONCLUSIONS

"BKO" JSC has perfected the production of block-shaped articles ShCU-33, ShSU-36, ShSU-40, and LMS-62 for the bottom lining of glass-making furnaces. The block-shaped articles with dimensions $1000 \times 400 \times 300$ mm are formed on a specialized German press K-500 "Fritz-Mueller" and are calcined in a tunnel furnace. Blocks with other dimensions are cut from these articles in accordance

with GOST 7151–74. Refractory article with a complicate configuration (for example, sections of feeder chutes) or with dimensions larger than the size of the bottom beam are made by vibrational casting from ultralow-cement concretes.

"BKO" JSC has perfected the construction of a preliminary stand assembly of the elements of glass-making furnaces: bottom, molten glass feeders, sub-checker arches, and other sectional structures. In the course of work on stand assembly the design and assembly of a stand were completed in house, the technology for cutting, grinding, and drilling large-block articles was perfected meeting stringent requirements for the tolerances:

– deviation of length, width, and height — ± 0.25 mm;

– bias (deviation from a right angle) on all sides — no more than 0.2 mm.

The stand and technological equipment available to "BKO" JSC and skilled workers make it possible to fill orders with assurance of quality meeting international standards.

The use of a stand assembly decreases considerably the time required to assemble a glass-making furnace and creates favorable conditions for laying other elements of a furnace, which together increase the service life of a glass-making furnace.